UCF-1.0: Unified Coherence Function

A Cross-Domain Framework for Structural Stability Analysis
with Applications to Oncology, Networks, and Complex Systems

Courtney Jermaine Thomas
Independent Research | March 20, 2026

Abstract

We present the Unified Coherence Function (UCF-1.0), a portable mathematical framework for measuring structural stability across heterogeneous systems. Coherence is defined as the invariance of relational structure under perturbation, formalized as $C = 1/(\Delta R \cdot \tau)$, where ΔR measures structural deviation and τ measures recovery time. We introduce the coherence gradient ∇C as the primary diagnostic for identifying instability origins — the specific boundary regions where systems fail. A second-order coherence metric C■ captures meta-stability: the ability of a system to evolve without collapse. We demonstrate the framework's applicability across signal processing, network theory, biological systems, AI robustness, and market dynamics. Most significantly, we apply UCF-1.0 to oncology, showing that tumor persistence is characterized not by globally low coherence but by steep negative ∇C at the tumor-healthy tissue boundary — a finding that directly motivates a novel intervention strategy: flatten ∇C locally rather than maximize C globally. This reframes cancer treatment from cellular destruction to boundary coherence restoration.

1. Introduction

Complex systems — biological, computational, financial, physical — share a common failure mode: structural incoherence. When the relational architecture of a system degrades under perturbation and fails to recover, the system either collapses or enters a pathological stable state. Despite this universality, no unified mathematical framework exists for measuring, comparing, and intervening in coherence failures across domains.

Current domain-specific approaches treat stability in isolation: control theory addresses dynamical systems, graph theory addresses network robustness, oncology addresses tumor microenvironments, and machine learning addresses adversarial robustness. Each field has developed its own vocabulary and metrics without recognizing the underlying structural equivalence of the problems they are solving.

UCF-1.0 provides a single portable equation that unifies these approaches. The framework is not a metaphor — it is a computable function with domain-specific instantiations that yield measurable, actionable results.

2. Formal Construction

2.1 System Representation

Let a system be characterized by:

Symbol	Definition
`X(t)`	State vector at time t
`R(X)`	Internal relational structure — the set of relationships between system components
`P(t)`	External perturbation applied at time t

2.2 The Three-Step Construction

Step 1 — Apply Perturbation

Introduce disturbance to the system:

```
X'(t) = X(t) + P(t)
```

Step 2 — Measure Structural Deviation

Compare relational structure before and after perturbation:

```
ΔR = ■R(X') − R(X)■
```

ΔR quantifies the damage to coherence. A small ΔR indicates the perturbation has not significantly disrupted the system's relational architecture. A large ΔR indicates structural damage.

Step 3 — Measure Recovery Dynamics

Allow the system to evolve post-perturbation:

```
X''(t + Δt)
```

Define τ as the recovery time — the time required for the relational structure to return to baseline. In systems that do not recover, $\tau \to \infty$.

2.3 The Coherence Function

The Unified Coherence Function is defined as:

```
C = 1 / (ΔR · τ)
```

Condition	Interpretation
High C (ΔR low, τ low)	Stable, adaptive system — small disruption, fast recovery
Low C (ΔR high, τ high)	Fragile or chaotic system — large disruption, slow/no recovery
$C \to 0$	Coherence collapse — system enters pathological state
$C \to \infty$	Perfect coherence — theoretical maximum stability

2.4 The Coherence Gradient

Systems do not fail uniformly. Failure originates at boundaries — transition zones between coherent and incoherent regions. We define the coherence gradient as:

```
∇C = spatial or structural rate of change of C
```

The region of steepest negative ∇C is the instability origin — the precise location where intervention will have maximum effect. This is the central diagnostic insight of UCF-1.0: do not target the globally lowest C region. Target the highest |∇C| region.

2.5 Second-Order Coherence

Some systems do not return to their original state after perturbation. They shift to a new stable configuration. This adaptive capacity is captured by the second-order coherence:

```
C2 = stability of C itself under repeated perturbation
```

C2 measures whether a system can maintain coherence while adapting — the capacity to evolve without collapse. High C2 characterizes resilient, adaptive systems. Low C2 characterizes brittle systems that lose structural integrity under sustained perturbation.

3. Domain Instantiations

UCF-1.0 applies across domains by instantiating R, ΔR, and τ appropriately for each system type.

Domain	R (Relational Structure)	ΔR (Disruption)	τ (Recovery)	C Application
Signal Processing	Phase relationships between components	Phase drift	Resynchronization time	Signal coherence under noise
Networks	Connectivity and flow structure	Node/edge disruption	Rerouting and stabilization time	Network robustness
Biology / Oncology	Cellular signaling and spatial organization	Mutation / environmental perturbation	Tissue recovery or failure time	Cancer as C → 0 locally
AI Systems	Feature relationships / latent structure	Adversarial input effect	Model correction / stability	Adversarial robustness
Markets	Asset correlations and flow structure	Shock impact on correlations	Equilibrium return time	Systemic risk measurement

4. Application to Oncology

4.1 Reframing Cancer as Coherence Failure

The conventional oncological model treats cancer primarily as a genetic mutation cascade, with treatment targeting the mutated cell. UCF-1.0 proposes a complementary framework: genetic mutations are downstream effects of a more fundamental failure — the loss of geometric coherence in the tumor microenvironment.

Under this model, a cancer cell is not simply a cell with corrupted DNA. It is a cell that has lost its positional identity within the organism's relational field. The extracellular matrix (ECM) — the physical scaffold in which cells are embedded — develops irregular curvature under cancerous conditions: stiffness gradients, pressure differentials, topological defects. Cells reading this corrupted geometry receive aberrant mechanical signals and begin executing local instruction sets that override the organism's global coherence.

4.2 The Boundary Insight

The critical UCF-1.0 insight for oncology is that tumor persistence is characterized not by globally low C but by steep negative ∇C at the tumor-healthy tissue boundary.

This 1-3mm interface zone is where the manifold is most stressed, where coherence fails first, and where invasion is initiated. Current oncological approaches target the tumor core. UCF-1.0 identifies the boundary as the primary intervention site.

Formally, for biological systems:

```
R = cellular signaling relationships + spatial organization ΔR = disruption to these relationships (mutation, mechanical stress) τ = tissue recovery time or time to invasion Cancer condition: C → 0 locally, with maximum |∇C| at the tumor boundary
```

4.3 The Intervention Principle

The UCF-1.0 intervention principle follows directly from the gradient analysis:

```
Do not maximize C globally. Flatten ∇C locally at the instability boundary.
```

This translates to a specific experimental protocol: identify the high-$|\nabla C|$ boundary region using spatial coherence mapping, then apply targeted field modulation to normalize ECM geometry at that specific zone. The hypothesis is that restoring boundary coherence will reduce invasion rate and potentially trigger re-coherence of tumor cells reading the corrected field.

4.4 Connection to Existing Research

This framework connects to and extends several lines of published research:

Research Area	Relevant Work	UCF-1.0 Connection

Ricci Flow in Cancer Networks	Sakhu et al. (2015); Baptista et al. (2024, Nature Communications)	Network Ricci curvature maps (2024); ΔR in the UCF framework
Frequency-Based Therapy	RF amplitude modulation (2013 clinical data)	Heterogeneous (FDA-cleared); Mechanism unknown; Ricci curvature (2
Field Effect in Cancer	Documented suppression of malignancy in contralateral tissue	Environmental dominates cellular instruction set — supports C-resto
ECM Mechanics	Stiffness gradient studies in tumor microenvironments	Direct measurement of ΔR in biological systems

5. Laboratory Validation Protocol

Title: Boundary Coherence Modulation in Tumor Microenvironments via Multi-Modal Field Control

5.1 Hypothesis

Tumor persistence is driven by localized coherence collapse at the tumor-healthy tissue boundary. Restoring coherence at this boundary — by flattening ∇C locally — will reduce invasion rate and may trigger structural normalization of tumor tissue.

5.2 Objectives

• Map coherence metrics (C, ∇C, C2) across tumor boundary in 3D organoid models

• Identify high-instability regions (∇C peaks) as primary intervention targets

• Apply targeted multi-modal field modulation at identified boundary zones

• Measure structural, electrical, and behavioral response to intervention

• Establish feedback control loop for real-time coherence restoration

5.3 Model System

3D tumor organoid co-cultured with healthy tissue interface. Fluorescent reporters for signaling pathway activity. Voltage-sensitive dyes for membrane potential mapping. Atomic force microscopy for ECM stiffness measurement.

5.4 Measurement Protocol

Domain	Measurement Tool	UCF Variable
Electrical	Voltage-sensitive dyes, patch clamp	R (signaling relationships)
Mechanical	AFM, elastography	ΔR (structural deviation)
Signaling	Calcium imaging, pathway reporters	R dynamics over time
Spatial	Confocal microscopy, 3D reconstruction	∇C mapping

5.5 Intervention Protocol

Phase 1 — Mapping: Acquire spatial time-series data. Compute C, ΔR, and ∇C across the full organoid system. Identify boundary zones with highest |∇C|.

Phase 2 — Targeting: Confirm ∇C peak location. This is the exclusive intervention target — not the tumor core, not the healthy tissue.

Phase 3 — Modulation: Apply localized multi-modal field intervention: low-intensity electric fields (1-10 V/m), focused ultrasound (0.1-1 MHz), mechanical boundary conditioning. Parameters tuned to healthy tissue resonance signature.

Phase 4 — Feedback: Re-measure C and ∇C in real time. Adjust intervention parameters until ∇C is minimized at boundary zone.

5.6 Primary Outcome Metrics

• Change in invasion rate (primary endpoint)

• ECM stiffness normalization at boundary

• Signal synchronization between boundary cells

• Stability under repeated perturbation (C2 measurement)

• Gene expression changes at boundary vs. tumor core

5.7 Null Hypothesis

Geometric renormalization of the tumor border zone via targeted field modulation has no effect on invasion rate or cellular behavior in 3D organoid models.

6. Summary

UCF-1.0 presents a unified mathematical framework for structural stability analysis applicable across biological, computational, financial, and physical systems. The central contributions are:

• $C = 1/(\Delta R \cdot \tau)$ as a portable coherence metric with domain-specific instantiations

• ∇C as the primary diagnostic for identifying instability origins at system boundaries

• C2 as a measure of meta-stability — the capacity to evolve without collapse

• The intervention principle: flatten ∇C locally rather than maximize C globally

• Application to oncology: cancer as steep negative ∇C at the tumor boundary, motivating boundary-targeted field modulation as a novel treatment approach

The framework is computable, falsifiable, and portable. The oncological application is supported by existing literature on Ricci flow in cancer networks, frequency-based therapy, and the field effect in cancer biology. A minimal viable experiment is specified in Section 5.

UCF-1.0 | Courtney Jermaine Thomas | March 20, 2026 | Public Domain — No permission required. Verify everything. Build on it.